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ABSTRACT

This curriculum guide contains nine units that provide the basic curriculum components required to develop lesson plans for the combined metal trades curriculum. This guide is not intended to be a complete, self-contained curriculum, but instead provides the teacher with a number of informational items related to the learning outcomes and allows the teacher flexibility to design instructional activities, select resources, and deliver instruction most appropriate for the learner and learning environment. The units of instruction contain the following components: learning outcomes; associated tasks; performance standards; lists of tools, equipment, resources, and limiting constraints; performance steps; and enabling objectives. The units cover the following topics: blueprint reading, sketching, and layout; hand tool and bench work; cutting and welding oxyacetylene; metallic and tungsten inert gas welding; pressing; drilling; power sawing; operating lathe; and operating milling machine. (KC)

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VOCATIONAL EDUCATION CURRICULUM GUIDE

INDUSTRIAL AND TECHNICAL EDUCATION

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Program Improvement Through

C·B·V·T·E

Competency Based Education

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Preface

The concept of competency based vocational-technical education has been supported by the Bureau of Vocational, Technical and Adult Education for a number of years. Since the early 1970's, the State has sponored the development and dissemination of numerous competency based curricula through the State Vocational Curriculum Laboratory. With the recent development of the State Master Plan for Public Education, however, the need to move rapidly toward systemwide adoption of this instructional concept in all schools is mandated by State Board of Education Policy.

According to the State Master Plan for Public Education, all instructional programs are to be learner oriented and described in terms of high quality, measurable, student centered outcomes (learning outcomes). In essence, this policy reinforces the competency-based vocational education philosophy.

Consistent with our current efforts in encouraging the implementation of vocational education learning outcomes, we have prepared this curriculum guide to assist vocational teachers as they prepare lesson plans that are reflective of the mandated core curriculum and defensible in terms of an equitable, quality vocational program.

Additional copies of this curriculum guide may be obtained from the:

West Virginia Vocational Curriculum Laboratory
Cedar Lakes Conference Center
Ripley, West Virginia 25271
Telephone: (304) 372-7021
Toll Free: 1-800-WVA-JOBS (in state)

Any suggestions you have for improving this material may be sent to your Vocational Curriculum Laboratory. Through this feedback, we plan to continually update and revise our materials.

VOCATIONAL, TECHNICAL AND ADULT EDUCATION

Clarence E. Burdette

Clarence E. Burdette
Assistant State Superintendent of Schools

Overview

The contents of this guide provide the basic curriculum components required to develop lesson plans that address the learning outcomes for this particular area of study. As such, this guide is not intended to be a complete, self-contained curriculum. Instead, the teacher is provided a number of informational items related to the learning outcomes and allowed the flexibility to design instructional activities, select resources and deliver instruction most appropriate for the learner and learning environment.

Specifically, this curriculum guide is organized in the following manner:

Units of Instruction (Where applicable)

A unit of instruction is a group or cluster of related learning outcomes that have been placed together for their similarity or main idea of task accomplishment. An example of a Unit would be Shielded Metal Arc Welding within the welding and cutting area of study.

Learning Outcomes

A learning outcome, oftentimes synomous with a competency statement, is a concise description of the curriculum in terms of desired learner behavior. Such statements are measurable, may contain one or more tasks and be action oriented. All approved learning outcomes for vocational education have undergone a strigent verification process with input from teachers and representatives of the business and/or industrial sector.

The approved learning outcomes for a specific vocational education area of study represent the core competencies of what has been identified as a quality vocational education experience. They do not, however, represent the entire instructional program for any area of study. It is hoped that all vocational instructors and local educational agencies will provide learners with educational experiences that exceed the "core competencies" identified through the learning outcomes.

Associated Tasks

A task represents an identifiable behavior that (1) has a purpose; (2) has a definite beginning and ending; (3) contains two or more steps none of which is a restatement of the original task statement if in the psychomotor domain; and (4) has a standard of performance which can be defined, described and verified. Learning outcome statements may be on the task level or may contain two or more independent tasks.

Examples of task/behavior statements are:

1. Chase external pipe threads.
2. Bleed diesel fuel system.
3. Use common standard medical abbreviations.
4. Prepare a resume.
5. Plan food experiences suitable for young children.

Performance Standards

The Standard is defined as criteria for assessing if tasks are performed or demonstrated as either acceptable or unacceptable. The performance standard communicates to the learner the quantity and quality of how well he or she is expected to complete the task. The standard can be stated in terms such as actual percentage of achievement, the accuracy expected, the number of errors permitted, the time allowed to complete the task, the degree, or any other appropriate level at which achievement is anticipated. The standard should be based on the performance level needed on the job.

Examples of standards are:

1. The circuit board must operate within the tolerances of the circuit design.
2. The estimate must be within + or -5% of that figured by the instructor.
3. Contacts must open when more than 125% of rated current value is made to pass through the overload relay heating element or coil.
4. The installation must be complete and each conductor must be terminated according to the schematic drawing of the design.
5. The motor must carry the load without being overloaded; the directions of rotation must be correct; belt must have a deflection of between 3/8" or 1/2".

Tools, Equipment, Resources and Situation(s)

Situation(s) is defined as the limiting constraints under which actions are to occur. The circumstances or restrictions imposed on the learner when he or she is demonstrating the behavior must be defined. Frequently, the conditions identify the testing situation used to determine learner achievement of the standard. Tools and equipment are the materials needed to perform the task being addressed in each performance standard.

Performance Steps

Performance steps are a series of steps required to perform a psychomotor task. The steps (1) are arranged in the sequence ordinarily followed on the job, (2) have a concise start and close, (3) are limited to the accompanying task statement, and

(4) are self-supporting and do not refer to actions beyond the task performance. Performance steps developed for each task are used to determine the enabling objectives and steps and procedures for performance checklist(s) to be utilized in assessing learner mastery of the task.

Enabling Objectives

Enabling objectives reflect the knowledges, attitudes and related skills the learner must possess in order to complete the task to the specified standard(s). As such, enabling objectives are derived from an instructional analysis of the task and/or performance steps and are stated in measurable terms of student performance.

Terms such as "define verbally," "construct," "diagram" and "list" are used to express enabling objectives, rather than obscure verbs like "know," "learn" and "understand". Examples of acceptable enabling objectives are:

1. List verbally the parts of a voltmeter.
2. Define Ohm's Law.
3. Explain relevant safety precautions and procedures.
4. Discriminate between types of life insurance policies.

Given this information for each outcome statement, the instructor is encouraged to develop the following components for lesson planning, delivery and evaluation.

Develop Instructional Activities

Instructional activities should be designed to provide the learner with experiences related to the enabling objectives, cumulating in successful task performance. The instructional activity section of a curriculum should contain a variety of strategies designed for the learners' varying learning styles and rates.

Consideration should be given to age, ability levels, educational levels, varied learning styles, individual interests, career goals, and emotional needs when developing the instructional activities. Activities should include suggestions for large groups, small groups and individual methods. The use of small groups may help students attain the skills, knowledge and attitudes associated with each task by making them (1) feel adequate and physically competent when they lack the necessary background information and experience; (2) feel a sense of security through the reenforcement of positive group attitudes; (3) gain confidence and discover that they are an essential part

of a team engaged in the learning-teaching process; (4) learn to work without direct supervision, and (5) vary instructional routines away from lecture or other full-class methods.

Identify Appropriate Instructional Resources

Instructional resources should be identified for each instructional activity and should be designed to help convey the message of the task and enabling objective(s). Attempts should be made to utilize modern instructional technology (i.e. television, computers, video-tapes, etc.) as much as possible in delivering the message desired. However, caution is advised in limiting the suggested resource section to only one alternative; due to the differing availability of resources between like programs across the state.

Provide Instruction

Many misconceptions exist about how an individual teacher must manage the instructional process when utilizing the competency based approach. Oftentimes CBE is considered synonmous with individualized instruction, wherein the instructor becomes the instructional manager of the educational process instead of the more traditional view of the teacher. Such misconceptions have led many educators to renounce competency based education as a means by which the teacher loses control and direction over the instructional process and is relegated to merely a role of record keeper.

The underlying concept of competency based instruction, however, does not dictate specific instructional procedures and method-ologies, but rather assures that those skills, knowledges and attitudes deemed essential for job success are taught, mastered to acceptable standards and documented. How this instruction is managed within the classroom, be it on a large group, small group or individualized basis should be left up to the instructor.

The content of the task itself and the enabling objectives dictate what should be taught. Thus, the instructional activities and supporting resources identified in the instructional plan must be designed to accommodate learner mastery of the subject matter. Where appropriate, this instruction may involve large group activities, smaller group participation and/or solely individualized study.

Where substantial diversity exists between ability and skill levels of the learners within a class, arrangements should be made to structure learning activities that accommodate this difference. This type of instructional arrangement is particularly crucial, given that one of the major premises of competency based instruction is that the learner be allowed to progress at his/her own pace and that this progression be based upon successful mastery of sequential competencies.

Also, another major consideration that must be given to providing competency-based instruction is the development of a mechanism whereby learners, due to prior experience or instruction, be allowed to "test out" on skills already attained without undue duplication of effort. This situation is most often addressed through the use of pretests prior to formal instruction.

*Evaluate Learner Performance

Evaluation of learner performance is one of the most critical steps in the instructional process. Criterion-referenced evaluative measures are advocated over the traditional norm-referenced approach due to the importance of all learners being able to perform to specialized standards. As such, the evaluation of learning outcomes and their related tasks should include means of assessing learner mastery of the knowledges, attitudes, and skills outlined in the enabling objectives and regarded as essential for completion of the learning outcomes/tasks, and also, learner performance of the learning outcomes/tasks to the performance standard.

In order to adequately evaluate learners, consideration must be given to constructing testing situations that address any or all of the three domains of learning encompassed within the learning outcome or task (i.e., psychomotor, cognitive, and affective).

*Note: The Bureau of Vocational, Technical and Adult Education is currently in the process or has developed comprehensive test item banks (written and performance) for a number of vocational education areas of study. For information relative to the availability of these item banks, contact the Assistant Director, Curriculum and Personnel Development.

Guide Coding System

Example: 4.2.3

4. - unit designation
2. - learning outcome under unit
3 - task under learning outcome

VOCATIONAL EDUCATION CURRICULUM GUIDE

METAL TRADES COMBINED

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PROGRAM OF STUDY : Industrial and Technical Education

AREA OF STUDY: Metal Trades Combined

UNIT # 1 Blueprint Reading, Sketching and Layout.

LEARNING OUTCOME # 1.1 Draw sketches for jobs with notes and symbols.

TASK # 1.1.1 Draw sketches for jobs with notes and symbols.

PERFORMANCE STANDARD: Sketch must show all views and dimensions required with job specification.

TOOLS, RESOURCES, EQUIPMENT, AND SITUATION(S):

Machinist's handbook
Measuring rule
Micrometers
Screw pitch gauge
Workpiece

PERFORMANCE STEPS:

1. Study workpiece.
2. Sketch view(s) of missing part.
3. Dimension sketch.
   a. Measure workpiece.
   b. Consult machinist's handbook for threads, fits, tapers, and tolerances.
   c. Calculate dimensions needed for machining part.
4. Check sketch dimensions against machining requirements.
5. Assure that views and dimensions meet job specifications.

ENABLING OBJECTIVES:

1. Explain views of drawing.
2. Demonstrate how to use drafting instruments.
3. Describe how to set and read micrometers.
4. Identify various thread forms.
5. List common symbols used on drawings.
6. Explain how to interpret specifications.

LEARNING OUTCOME # 1.2 Interpret technical orders, standards, and specifications for work applications.

TASK # 1.2.1 Interpret technical orders, standards, and specifications for work applications.

PERFORMANCE STANDARD: Technical orders, standards, and specifications must be interpreted so as to produce specific work application stated on work order.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Not applicable

PERFORMANCE STEPS:

Not applicable

ENABLING OBJECTIVES:

1. Read and understand technical terminology.
2. Read and apply standards for work to be performed.
3. Read and apply specifications for work to be performed.
4. Read and interpret drawings and schematics.
5. Demonstrate how to use drafting instruments and define.
6. List and define common symbols used on drawings and schematics.

LEARNING OUTCOME # 1.3 Layout work using layout tools.

TASK # 1.3.1 Layout work using layout tools.

PERFORMANCE STANDARD: Scribed lines must be within +- 1/64" of specified dimensions.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprint	Scriber
Compass	Square
Layout fluid	Stock

PERFORMANCE STEPS:

1. Read blueprint to determine dimensions.
2. Clean surface of stock.
3. Apply layout fluid.
4. Layout overall dimensions.
5. Locate center lines.
6. Scribe circles and arcs.
7. Scribe straight lines.

ENABLING OBJECTIVES:

1. Demonstrate how to accurately read a rule.
2. Identify center lines.
3. Differentiate between diameter and radius.
4. Define the term tangent.
5. Demonstrate how to sharpen a scriber.
6. Explain converting inches to decimals.
7. Explain metric conversion.

LEARNING OUTCOME # 1.4 Machine, cut, weld, or form material to blueprint specifications.

TASK # 1.4.1 Machine, cut, weld, or form material to blueprint specifications.

PERFORMANCE STANDARD: Workpiece must be machine, cut, welded, and formed to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Bench equipment
Blueprint
Materials
Reference material

PERFORMANCE STEPS:

1. Study blueprint.
2. Select materials to be used.
3. Determine logical sequence for cutting, welding, machining, and forming material.
4. Obtain equipment, accessories, and supplies to perform work required.
5. Manufacture part according to blueprint specifications.
6. Check workpiece against blueprint specifications.
   a. Correct as necessary.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. List the operations that can be performed on the following machinery: lathe, drill press, arbor press, milling machine, surface grinders, TIG welder, MIG welder, gas welder, and arc welder.

3. Define and list examples of ferrous and non-ferrous materials.
4. Describe how to interpret blueprints.
5. Explain how to select tools, machines, and materials.

UNIT #2 Hand tool and bench work.

LEARNING OUTCOME # 2.1 Use and maintain non-edged and edged hand tools.

TASK # 2.1.1 Use and maintain non-edged and edged hand tools.

PERFORMANCE STANDARD: All tools must be free of rust, grease, and broken or defective parts. Edged tools must be sharp, with no broken teeth. Blades must be sharpened to manufacturer's specifications. Punches and chisels must not have mushroom heads. All tools must be stored in designated case or cabinet.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Cleaning solvent	Lubricating oil
Crocus cloth	Machinist's handbook
Grinder	Personal safety equipment
Hand tools	Rags

PERFORMANCE STEPS:

1. Inspect hand tool and determine damage.
   a. Cutting tools must be sharp with no broken teeth.
   b. Clamping tools must have clean jaws and screws.
   c. Soft jaws must be available for vises.
   d. Screwdrivers must have correctly shaped blade.
   e. Punches and chisels must not have mushroom heads.
2. Obtain any needed parts.
   a. Dismantle and replace damaged part.
   b. Make required adjustments.
3. Sharpen dull tools.
   a. Check for mushroom heads.
   b. Check angle of cutting edge.
   c. Regrind shape as required.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify the relevant sections of machinist's handbook.
3. Demonstrate setting up and operating grinder.
4. Demonstrate how to sharpen chisel and prick punches.
5. List the cleaning solvents and their uses on respective tools.
6. List the abrasive materials and their uses on respective tools.

LEARNING OUTCOME # 2.2 — Use and maintain semi-precision and precision measuring tools.

TASK # 2.2.1 — Use and maintain semi-precision and precision measuring tools.

PERFORMANCE STANDARD: Measuring tools must be aligned and must be free of rust and grease. All bright surfaces must be lightly coated with lubrication oil. All instruments must be stored in designated case/cabinet, which must be humidity controlled.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Cleaning solvents	Precision and semi-precision tools
Crocus cloth	Rags
Lubricating oil	Tools

PERFORMANCE STEPS:

1. Remove all grease from instruments.
   a. Apply cleaning solution.
   b. Wipe surfaces clean and dry.
2. Remove all rust from instrument surfaces.
   a. Apply rust remover.
   b. Wipe surfaces with crocus cloth.
   c. Burnish surfaces with crocus cloth.
3. Coat lightly all bright surfaces with lubricating oil.
4. Insure instrument is aligned.
   a. Check instrument with standard.
   b. Adjust instrument to standard or zero reading.
5. Store instrument.
   a. Place in designated instrument case and/or
   b. Place in designated storage cabinet.
   c. Place in humidity controlled area.

b. Place in designated storage cabinet.
c. Place in humidity controlled area.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify abrasives for cleaning.
3. List various types of micrometers.
4. Explain calibrating various types of micrometers.
5. Define the term burnish.
6. Explain the effects of heat and extreme cold on precision instruments.

LEARNING OUTCOME # 2.3 Use and maintain work holding devices, taps, dies, and hand held power tools.

TASK # 2.3.1 Use and maintain work holding devices, taps, dies, and hand held power tools.

PERFORMANCE STANDARD: Tools must be free of rust, grease, sharpened and stored in designated case/cabinet.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Cleaning solvent
Crocus cloth
Hand tools
Lubricating oil
Rags

PERFORMANCE STEPS:

1. Inspect work holding devices and determine damage if applicable.
   a. Clean lead screw.
   b. Lubricate lead screw.
   c. Clean saw face.
   d. Deburr saw face.
2. Inspect taps and dies for damage, if applicable.
   a. Clean and lubricate.
   b. Replace damage taps and dies.
3. Inspect power tool and determine damage, if applicable.
   a. Replace damaged cords and plugs.
   b. Lubricate chucks.
   c. Assure that switch functions according to specification.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify the relevant sections of machinist's handbook.
3. Explain polarized plugs and three prong plugs.
4. Identify neutral and line leads of electric motors.
5. Describe cutting action of taps and dies.
6. Demonstrate safe use of electric drills and portable hand grinders.
7. Identify classification of abrasive grit numbers.

UNIT #3 Cutting and Welding Oxy-Acetylene.

LEARNING OUTCOME # 3.1 Select, clean, set-up, and test oxy-acetylene welding equipment.

TASK # 3.1.1 Select, clean, set-up, and test oxy-acetylene welding equipment.

PERFORMANCE STANDARD: Oxy-acetylene equipment must be clean and set up according to manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Abrasive	Oxy-acetylene welding equipment
Brushes	Oxy-acetylene welding torch
Clamps	Personal safety equipment

PERFORMANCE STEPS:

1. Attach regulators to tanks.
2. Attach hoses to regulators.
3. Attach torch to lose.
4. Install torch tip.
   a. Clean if necessary.
5. Open tank valves and adjust pressure.
6. Turn on acetylene and light.
7. Turn on oxygen and adjust to neutral flame.
8. Turn off oxygen.
9. Turn off acetylene.
10. Turn off tank valves.
11. Bleed lines.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Demonstrate how to set-up an oxy-acetylene welding system.
3. Demonstrate how to clean an oxy-acetylene welding system.
4. Explain the importance of keeping such a system clean.
5. Demonstrate how to test an oxy-acetylene welding system.
6. Explain the difference between a neutralizing flame and an oxidizing flame.
7. Demonstrate how to bleed the lines on an oxy-acetylene welding system.
8. Discuss the importance of bleeding the lines.

LEARNING OUTCOME #	3.2	Weld, braze, and solder with oxy-acetylene welding equipment in all positions on carbon steel.
TASK(S) #	3.2.1	Weld with oxy-acetylene in all positions on carbon steel.
	3.2.2	Braze with oxy-acetylene in all positions on carbon steel.
	3.2.3	Solder with oxy-acetylene in all positions on carbon steel.
TASK #	3.2.1	Weld with oxy-acetylene in all positions on carbon steel.

PERFORMANCE STANDARD: Welds must be as strong as workpieces; and visual inspection must show even weld beads, penetration of parent metal and complete fusion with smooth even beads without cracks, holes, craters, or undercut.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

- Abrasive
- Apron
- Brush
- Clamps
- Oxy-acetylene welding equipment
- Oxy-acetylene welding torches
- Personal safety equipment
- Soapstone or chalk
- Tongs
- Welding goggles

PERFORMANCE STEPS:

NOTE: The Performance Steps for all four positions (flat, horizontal, vertical, and overhead) are identical and as follows:

1. Set up welding equipment.
2. Ventilate work area.
3. Inspect work area for flammable materials. Remove any flammable materials.
4. Prepare metal to be welded.
   a. Cleaning.
   b. Grinding.
   c. Positioning.
5. Select torch tip, filler rod, and (flux for non-ferrous metals).
6. Open tank valves and adjust pressure to specified readings on regulators.
7. Turn on/light and adjust torch to neutral flame.
8. Preheat workpiece.
9. Apply flux.
10. Weld joints to work order specifications.
11. Shut off equipment.
12. Bleed lines.
13. Clean and allow weld to cool.
14. Check weld for undercut, cracks, or porosity.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify the parts of an oxy-acetylene welding system.
3. Identify the parts of an oxy-acetylene torch.
4. Differentiate between different size welding tips for an oxy-acetylene.
5. Explain the effects of heat on various types of material to be welded.
6. Define a neutral flame and an oxidizing flame.
7. Explain the tempering and annealing processes.
8. Explain the techniques for surface preparation.
9. List the various types of filler rods.
10. Explain the purpose of pressure regulator valves on the system.
11. Identify the various fluxes available and their application.
12. Discuss the properties of carbon steel.

TASK # 3.2.2 Braze with oxy-acetylene in all positions on carbon steel.

PERFORMANCE STANDARD: Brazed joints must have uniform beads and bond with smooth even puddles without holes, craters, or undercut.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

- Abrasive
- Apron
- Clamps
- Oxy-acetylene torches
- Oxy-acetylene welding equipment
- Personal safety equipment
- Soapstone or chalk
- Steel brush
- Tongs
- Welding goggles

PERFORMANCE STEPS:

1. Set up welding equipment.
2. Ventilate work area.
3. Inspect work area for flammable materials. Remove if necessary.
4. Prepare metal for brazing by cleaning, grinding, positioning.
5. Select torch tip, filler rod, brazing flux.
6. Turn on/light and adjust torch to neutral or slight oxidizing flame.
7. Heat joint and filler rod and apply flux.
8. Tack joint on each end.
9. Check alignment.
10. Tin joint and braze.
11. Shut off equipment and bleed lines.
12. Clean and cool workpiece(s).
13. Check braze.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify different types of brazing rods and their applications.
3. Identify different types of fluxes and their applications.
4. Identify parts of oxy-acetylene welding system.
5. Differentiate between the different size tips for an oxy-acetylene torch.
6. Explain possible outcome with <u>not</u> tack brazing work piece.
7. Explain effects of heat on material.
8. List materials that are not easily brazed.
9. Identify a neutral flame and an oxidizing flame.
10. Explain tempering and annealing processes.
11. Explain importance of and procedures for surface preparation.

TASK # 3.2.3 Solder with oxy-acetylene in all positions on carbon steel.

PERFORMANCE STANDARD: Soldered joints must be smooth, continuous, bonded, and completely sealed.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Abrasive
Apron
Brush
Clamps
Flux
Gas welding equipment
Personal safety equipment
Tongs
Welding goggles/safety glasses

PERFORMANCE STEPS:

1. Set up equipment.
2. Ventilate work area.
3. Inspect work area for flammable materials.
   a. Remove flammable materials.
4. Select flux for metal used.
5. Prepare metal for soldering.
   a. Clean.
   b. Flux.
   c. Position.
6. Select welding tip and regulator pressures.
7. Open tank valves and adjust pressure.
8. Turn on/light and adjust torch to neutral flame.
9. Heat metal surface.
10. Apply solder.
11. Shut off equipment.
12. Cool and clean joints.
13. Check joints for bond, holes, smoothness, and capillary action.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Define the terms ferrous and non-ferrous.
3. Differentiate between various grades of solder.
4. Differentiate between soldering, brazing, and welding.
5. List various types of fluxes used for soldering.
6. Demonstrate how to clean torch tips.
7. List tip sizes and their applications.

LEARNING OUTCOME # 3.3 Operate oxy-acetylene cutting equipment to make straight cuts, bevel edges, and holes.

TASK # 3.3.1 Operate oxy-acetylene cutting equipment to make straight cuts, bevel edges, and holes.

PERFORMANCE STANDARD: Cuts must be within a tolerance of American Welding Society criteria for cut surfaces.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

- Apron
- Center punch
- Hammer
- Manufacturer's specifications for oxy-acetylene welding equipment
- Oxy-acetylene cutting equipment
- Oxy-acetylene cutting torches
- Personal safety equipment
- Rule
- Soapstone or chalk
- Steel brush
- Tongs
- Welding goggles

PERFORMANCE STEPS:

1. Set up welding equipment.
2. Ventilate work area.
3. Inspect work area for flammable materials.
   a. Remove flammable materials.
4. Post fire watch if necessary.
5. Determine grade of steel by:
   a. Spark stream, or
   b. Code number.
6. Lay out cuts.
7. Select torch tip according to equipment manufacturer's specifications.
8. Open tank valves and adjust pressure to specified readings on regulators according to manufacturer's specifications.
9. Turn on/light and adjust torch to neutral flame with cutting oxygen.
10. Cut metal to specifications.
11. Close tank valves and bleed lines.
12. Cool metal.
13. Check cuts and dimensions.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify grades of steel.
3. Identify the parts of a cutting torch.
4. Determine tank pressure settings for various torch tips sizes.
5. Explain layout procedure for cutting.

LEARNING OUTCOME # 3.4 Prepare weldment joints.

TASK # 3.4.1 Prepare weldment joints.

PERFORMANCE STANDARD: Joint must be aligned and clamped for tack weld. Surfaces must be cleaned and tapered according to blueprint specification.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprint
Clamps
Hand grinder
Material
Personal safety equipment

PERFORMANCE STEPS:

1. Determine type of joint to be welded.
2. Determine material of workpiece.
3. Select appropriate type of welding equipment.
4. Remove rust and scale from joint area.
5. Face tapers or bevels required.
6. Align workpieces.
7. Clamp workpiece to obtain snug fit.

ENABLING OBJECTIVES.

1. Explain the relevant safety practices and procedures.
2. Identify types of joints.
3. Differentiate between ferrous and non-ferrous material explaining the difference.
4. List various types of welding equipment.
5. Explain the purpose of tack welding.
6. Identify various welding positions.
7. Describe techniques for securing workpieces together.

UNIT #4 Metallic and tungsten inert gas welding.

LEARNING OUTCOME # 4.1 Select, prepare, adjust, and operate gas metal arc welding (MIG) and gas tungsten arc (TIG) welding equipment.

TASK(S) # 4.1.1 Select, prepare, adjust, and operate metallic inert gas welder (MIG).

4.1.2 Select, prepare, adjust, and operate tungsten inert gas welder (TIG).

TASK # 4.1.1 Select, prepare, adjust, and operate metallic inert gas welder (MIG).

PERFORMANCE STANDARD: MIG welding unit must be prepared and adjusted for operation according to manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Clamps
Filler rod
Manufacturer's specifications for MIG welding unit
MIG welding unit
Personal safety equipment

PERFORMANCE STEPS:

1. Set up equipment.
2. Ventilate work area.
3. Inspect work area for flammable materials.
   a. Remove flammable materials.
4. Prepare metal to be welded.
   a. Clean.
   b. Grind.
   c. Position.
5. Position all cables and hoses so they are neither burned or damaged.
6. Attach ground cable.
7. Turn on electrical equipment.
8. Turn on/adjust water flow.
9. Turn on/adjust shielding gas.
10. Adjust wire feed, voltage, amperage, and stick-out.
11. Shut off equipment.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Describe the components of a MIG welder.
3. Describe how a MIG welder functions.
4. Differentiate between ferrous and non-ferrous metals.
5. Identify special condition for welding in vertical, horizontal, and overhead positions.
6. Explain the advantages of MIG welding.
7. Differentiate between striking an arc on a MIG welder and a shielded arc welder.
8. Explain surface preparation techniques for MIG welding.
9. Describe filler rods available and their applications.
10. List types of metals that can be welded with MIG.

TASK # 4.1.2 Select, prepare, adjust, and operate tungsten inert gas welder (TIG).

PERFORMANCE STANDARD: TIG welding unit must be prepared and adjusted for operation according to manufacturer's specification.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Clamps
Filler rod
Manufacturer's specifications for TIG welding unit
Personal safety equipment
TIG welding unit

PERFORMANCE STEPS:

1. Set up equipment.
2. Ventilate work area.
3. Inspect work area for flammable materials.
   a. Remove flammable materials.
4. Prepare metal to be welded.
   a. Clean.
   b. Grind.
   c. Position.
5. Position all cables and hoses so they are neither burned or damaged.
6. Attach ground cable.
7. Turn on electrical equipment.
8. Turn on and check water flow as required.
9. Turn on/adjust shielding gas.
10. Select/adjust tungsten.
11. Adjust current.
12. Adjust high frequency.
13. Shut off equipment.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Describe the components of a TIG welder.
3. Describe how a TIG welder functions.
4. Explain advantages and disadvantages of TIG system.
5. Differentiate between striking an arc with a TIG unit and a shielded arc welder.
6. Explain surface preparation techniques for TIG welding.
7. Describe filler rods available and their applications.
8. List type of metals that can be welded with TIG equipment.

LEARNING OUTCOME # 4.2 Prepare, position, and tack weld parts.

TASK # 4.2.1 Prepare, position, and tack weld parts.

PERFORMANCE STANDARD: Tack welds must hold work in position and prevent warping of workpiece.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Clamps
Fixtures
Personal safety equipment
Welding equipment and accessories
Welding rods

PERFORMANCE STEPS:

1. Select safety and welding equipment.
2. Select clamps, fixtures, and tools.
3. Set up, align, and clamp workpieces in position.
4. Select correct rod and/or electrodes and set up equipment.
5. Tack weld pieces in position.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify types of welding equipment.
3. Describe how welding machines operate.
4. Identify types of welding rods.
5. Describe types of weld joints.
6. Demonstrate how to align workpieces.
7. Explain the term tack weld.

LEARNING OUTCOME # 4.3 Operate MIG and TIG welding equipment to weld carbon steel; beads, padding, and all joints in the flat, horizontal, vertical, and overhead positions.

TASK(S) # 4.3.1 Operate MIG welding equipment to weld carbon steel; beads, padding, and all joints in flat, horizontal, vertical, and overhead positions.

4.3.2 Operate TIG welding equipment to weld carbon steel; beads, padding, and all joints in flat, horizontal, vertical, and overhead positions.

TASK # 4.3.1 Operate MIG welding equipment to weld carbon steel; beads, padding, and all joints in flat horizontal, vertical, and overhead positions.

PERFORMANCE STANDARD: Weld must be as strong as original material and part or workpiece must function as designed. Visual inspection of joints must show smooth and continuous welds, complete penetration, fusion between weld bead and base metal, with no cracks, undercutting or overlap.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Clamps
Filler rod
MIG welding unit
Personal safety equipment

PERFORMANCE STEPS:

1. Set up equipment.
2. Ventilate work area.
3. Inspect work area for flammable materials.
   a. Remove flammable material.
4. Prepare metal to be welded.
   a. Clean.
   b. Grind.
   c. Position.
5. Position all cables and hoses so they are neither burned or damaged.
6. Attach ground cable.
7. Turn on electrical equipment.
8. Turn on/adjust water flow.
9. Turn on/adjust shielding gas.
10. Adjust wire feed, voltage, amperage, and stick-out.
11. Weld joints using fillet and groove welds in all positions according to work order.
12. Shut off equipment.
13. Clean welds and cool.
14. Check/test welds.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify special condition for welding in vertical, horizontal, and overhead positions.
3. Explain the advantages of MIG welding carbon steel.
4. Differentiate between striking an arc on a MIG welder and a shielded arc welder.
5. Explain surface preparation techniques for carbon steel.
6. Define fillet weld.
7. Define groove weld.
8. Discuss the properties of carbon steel.

TASK # 4.3.2 Operate TIG welding equipment to weld carbon steel; beads, padding, and all joints in flat, horizontal, vertical, and overhead position.

PERFORMANCE STANDARD: Weld must be as strong as the workpieces. Visual inspection of joints must show smooth and continuous welds, complete penetration, fusion between weld bead and base metal, with no cracks, undercutting, or overlap.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Clamps
Filler rod
Personal safety equipment
TIG welding unit

PERFORMANCE STEPS:

1. Set up equipment.
2. Ventilate work area.
3. Inspect work area for flammable materials.
   a. Remove flammable materials.
4. Prepare metal to be welded.
   a. Clean.
   b. Grind.
   c. Position.
5. Position all cables and hoses so they are neither burned or damaged.
6. Attach ground cable.
7. Turn on electrical equipment.
8. Turn on/adjust water flow.
9. Turn on/adjust shielding gas.
10. Select/adjust tungsten.
11. Adjust current.
12. Adjust high frequency.
13. Weld joints in all positions according to work order.
14. Shut off equipment.
15. Clean welds and cool.
16. Check/test welds.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Describe the components of a TIG welder.
3. Describe how a TIG welder functions.
4. Differentiate between ferrous and non-ferrous metals.
5. Identify special conditions for welding in various position: horizontal, vertical, and overhead.

6. Explain the advantages and disadvantages of TIG weld system.
7. Differentiate between striking an arc with a TIG unit and a shielded arc welder.
8. Explain surface preparation techniques for TIG welding on carbon steel.
9. Demonstrate how to clean welds.

LEARNING OUTCOME # 4.4 Operate MIG and TIG welding equipment to weld aluminum and aluminum alloys in all positions.

TASK(S) # 4.4.1 Operate MIG welding equipment to weld aluminum and aluminum alloys in all positions.

4.4.2 Operate TIG welding equipment to weld aluminum and aluminum alloys in all positions.

TASK # 4.4.1 Operate MIG welding equipment to weld aluminum and aluminum alloys in all positions.

PERFORMANCE STANDARD: Weld must be as strong as original material and part or workpiece function as designed. Visual inspection of joints must show smooth and continuous welds, complete penetration, fusion between weld bead and base metal, with no cracks, undercutting, or overlap.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Clamps
Filler rod
MIG welding unit
Personal safety equipment

PERFORMANCE STEPS:

1. Set up equipment.
2. Ventilate work area.
3. Inspect work area for flammable materials.
   a. Inspect work area for flammable materials.
4. Prepare metal to be welded:
   a. Clean.
   b. Grind.
   c. Position.
5. Position all cables and hoses so they are neither burned or damaged.
6. Attach ground cable.

7. Turn on electrical equipment.
8. Turn on/adjust water flow.
9. Turn on/adjust shielding gas.
10. Adjust wire feed, voltage, amperage, and stick-out.
11. Weld joints using fillet and groove welds in all positions according to work order.
12. Shut off equipment.
13. Clean welds and cool.
14. Check/test welds.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify special condition for welding on vertical, horizontal, and overhead positions.
3. Explain the advantages of MIG welding on aluminum and aluminum alloys.
4. Differentiate between striking an arc on a MIG welder and a shielded arc welder.
5. Explain surface preparation techniques for aluminum.
6. Describe filler rods available and their applications.
7. List other types of metals that can be welded with MIG equipment.
8. Discuss the properties of aluminum and aluminum alloys.
9. List aluminum alloys.

TASK # 4.4.2 Operate TIG welding equipment to weld aluminum and aluminum alloys in all positions.

PERFORMANCE STANDARD: Weld must be as strong as the workpieces. Visual inspection of joints must show smooth and continuous welds, complete penetration, fusion between weld bead and base metal, with no cracks, undercutting, or overlap.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Clamps
Filler rod
Personal safety equipment
TIG welding unit

PERFORMANCE STEPS:

1. Set up equipment.
2. Ventilate work area.
3. Inspect work area for flammable materials.
   a. Remove flammable materials.

4. Prepare metal to be welded:
   a. Clean.
   b. Grind.
   c. Position.
5. Position all cables and hoses so they are neither burned or damaged.
6. Attach ground cable.
7. Turn on electrical equipment.
8. Turn on/check water flow.
9. Turn on/adjust shielding gas.
10. Select/adjust tungsten.
11. Adjust current.
12. Adjust high frequency.
13. Weld joints in all positions according to work order.
14. Shut off equipment.
15. Clean welds and cool.
16. Check/test welds.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify special conditions for welding in various position: horizontal, vertical, and overhead.
3. Explain the advantages and disadvantages of TIG system on aluminum and aluminum alloys.
4. Differentiate between striking an arc with a TIG unit and a shielded arc welder.
5. Explain surface preparation techniques for aluminum.
6. Describe filler rods available and their applications.
7. List other types of metals that can be welded with TIG equipment.

LEARNING OUTCOME #	4.5	Operate MIG and TIG welding equipment to weld steel and stainless steel alloys in all positions.
TASK(S) #	4.5.1	Operate MIG welding equipment to weld steel and stainless steel alloys in all positions.
	4.5.2	Operate TIG welding equipment to weld steel and stainless steel alloys in all positions.
TASK #	4.5.1	Operate MIG welding equipment to weld steel and stainless steel alloys in all positions.

PERFORMANCE STANDARD: Weld must be as strong as original material and part or workpiece must function as designed. Visual inspection of joints must show smooth and continuous welds, complete penetration, fusion between the weld bead and base metal, with no cracks, undercutting, or overlap.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Clamps
Filler rod
Personal safety equipment
MIG welding unit

PERFORMANCE STEPS:

1. Set up equipment.
2. Ventilate work area.
3. Inspect work area for flammable materials.
   a. Remove flammable materials.
4. Prepare metal to be welded:
   a. Clean.
   b. Grind.
   c. Position.
5. Position all cables and hoses so they are neither burned or damaged.
6. Attach ground cable.
7. Turn on electrical equipment.
8. Turn on/adjust water flow.
9. Turn on/adjust shielding gas.
10. Adjust wire feed, voltage, amperage, and stick-out.
11. Weld joints using fillet and groove welds in all positions according to work order.
12. Shut off equipment.
13. Clean welds and cool.
14. Check/test welds.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Describe the components of a MIG welder.
3. Describe how a MIG welder functions.
4. Differentiate between ferrous and non-ferrous metals.
5. Identify the special conditions for welding in vertical, horizontal, and overhead positions.
6. Explain the advantages of MIG welding on steel and stainless steel alloys.

7. Differentiate between striking an arc on a MIG welder and a shielded arc welder.
8. Explain surface preparation techniques for steel and stainless steel alloys.
9. Describe filler rods available and their applications.
10. List other types of metals that can be welded with MIG equipment.

TASK # 4.5.2 Operate TIG welding equipment to weld steel and stainless steel alloys in all positions.

PERFORMANCE STANDARD: Weld must be as strong as workpieces. Visual inspection of joints will show smooth and continuous welds, complete penetration, fusion between the weld bead and base metal, and no cracks, undercutting or overlap.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Clamps
Filler rod
Personal safety equipment
TIG welding unit

PERFORMANCE STEPS:

1. Set up equipment.
2. Ventilate work area.
3. Inspect work area for flammable materials.
   a. Remove if necessary.
4. Prepare metal to be welded by cleaning, grinding, positioning.
5. Position all cables and hoses so they are neither burned or damaged.
6. Attach ground cable.
7. Turn on electrical equipment.
8. Turn on/check water flow as required.
9. Turn on/adjust shielding gas.
10. Select/adjust tungsten.
11. Adjust current.
12. Adjust high frequency.
13. Weld joints in all positions according to work order.
14. Shut off equipment.
15. Clean welds and cool.
16. Check/test welds.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Describe components of a TIG welder.
3. Describe how a TIG welder functions.

4. Differentiate between ferrous and non-ferrous metals.
5. Identify the special conditions for welding in various position: horizontal, vertical, and overhead.
6. Explain the advantages and disadvantages of TIG system on steel and stainless steel.
7. Differentiate between striking an arc with a TIG unit and a shielded arc welder.
8. Explain surface preparation techniques.
9. Describe filler rods available and their applications.
10. List type of metals that can be welded with TIG equipment.
11. List the properties of steel and stainless steel alloys.

UNIT #5 Pressing.

LEARNING OUTCOME # 5.1 Clean, lubricate, service, and inspect arbor and hydraulic presses.

TASK(S) # 5.1.1 Clean, lubricate, service, and inspect arbor presses.

5.1.2 Clean, lubricate, service, and inspect hydraulic presses.

TASK # 5.1.1 Clean, lubricate, service, and inspect arbor presses.

PERFORMANCE STANDARD: Arbor press must be cleaned, lubricated, and adjusted to manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Arbor press
Brush
Cleaning solvent
Lubricants
Personal safety equipment
Rags

PERFORMANCE STEPS:

1. Brush off all chips.
2. Wash grease and oil from table and ram.
3. Deburr table and ram head.
4. Coat ram and table lightly with oil.
5. Adjust and lubricate rack and pinion.
6. Clean wheel handle.
7. Grease fitting according to manufacturer's specifications.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify the parts of arbor press.
3. Describe how an arbor press operates.
4. Identify the various lubricants used for arbor presses.
5. Identify cleaning solvents and their applications.
6. Differentiate between oil and grease.

TASK # 5.1.2 Clean, lubricate, service, and inspect hydraulic presses.

PERFORMANCE STANDARD: Hydraulic press must be clean, lubricated, and adjusted to manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Brush
Cleaning solvents
Hydraulic press
Lubricants
Manufacturer's specifications for hydraulic press
Personal safety equipment
Rag

PERFORMANCE STEPS:

1. Shut off power.
2. Brush off all chips.
3. Wash grease and oil from machine surfaces.
4. Deburr table and column if necessary.
5. Coat ram and tables lightly with oil.
6. Check hydraulic fluid level.
   a. Replace fluid if dirty.
   b. Clean screen and filters.
   c. Fill to right windows.
7. Adjust pressure switches and controls to manufacturer's specifications.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify the parts of a hydraulic press.
3. Explain how a hydraulic press operates.
4. Identify lubricants for hydraulic press.
5. Identify the characteristics of hydraulic fluid.
6. Identify cleaning solvents and their applications and limitations.
7. Explain hydraulic principles.

LEARNING OUTCOME # 5.2 Set up, assemble, and disassemble parts.

TASK # 5.2.1 Set up, assemble, and disassemble parts.

PERFORMANCE STANDARD: Parts must be disassembled or assembled to a tolerance of +- 1/64".

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Arbor press/hydraulic press
Clamps

PERFORMANCE STEPS:

1. Perform set up:
   a. Take and record measurement of position of part to be removed.
   b. Place and clamp stationary part to table.
   c. Align moveable part in accordance to ram.
2. Remove part:
   a. Lubricate both part(s).
   b. Check disassembly procedures.
   c. Check for keys, set screws, and tapers or shoulders.
   d. Apply pressure to remove part (if gauges are available, check pressure of operation).
   e. Remove part(s).
3. Replace part(s):
   a. Lubricate both parts.
   b. Check disassembly procedures.
   c. Align keyways or matching parts.
   d. Apply lubricants to all parts.
   e. Press parts together.
   f. Check tolerance as measured in Step #1.
   g. Approve assembly, or
   h. Disapprove assembly and/or take corrective action.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify how to use measuring instruments.
3. Identify types of penetrating oils and lubricants.
4. Identify the function of arbor press.
5. Describe operation of the hydraulic press and the arbor press.
6. Define the terms pressed fit, and heat shrink fit.

LEARNING OUTCOME # 5.3 Bend and straighten parts.

TASK # 5.3.1 Bend and straighten parts.

PERFORMANCE STANDARD; Workpiece must be straightened or bent to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Arbor press
Dial indicator
Personal safety equipment
Support blocks
Work-holding device

PERFORMANCE STEPS:

1. Determine length and diameter of shaft.
2. Obtain support blocks.
   NOTE: Assure protection of shaft from flat spots when straightening.
3. Locate and mark high spot on shaft.
4. Place center of high point of bent shaft in press.
5. Apply pressure on shaft sufficient to straighten it by operating press.
   a. Check amount of spring back.
6. Remove shaft.
7. Roll shaft on surface plate or other known flat surface.
8. Check for straightness with scale.
9. Re-straighten as necessary.
   a. Check spring back.
10. Clamp in lathe between centers.
11. Rotate slowly and measure runout with dial indicator.
12. Repeat steps #3-11 until shaft is straight to specifications.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify the parts of arbor press.
3. Explain work holding techniques for arbor press.
4. Define terms spring back and high point.
5. Explain how to set-up and read dial indicators.

LEARNING OUTCOME # 5.4 Set-up and broach with press.

TASK # 5.4.1 Set-up and broach with press.

PERFORMANCE STANDARD: Workpiece must be broached within tolerance of +- 0.001" on decimal dimensions and +-

1/64" on fraction dimensions.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

- Arbor press/hydraulic press
- Broach guides
- Broaching tool
- Personal safety equipment
- Precision measuring instruments
- Work supports

PERFORMANCE STEPS:

1. Clean and deburr workpiece.
2. Mount work and supports on arbor press.
3. Select broaching tool and guides.
4. Align broaching tool on workpiece.
   a. Check ram wear on arbor press.
   b. Check vertical alignment of broaching tool.
5. Press broaching tool through workpiece.
   a. Use lubricant except on cast iron.
   b. Repeat cut with shims if necessary.
6. Check measurement of workpiece.
   a. Accept workpiece, or
   b. Reject workpiece and/or take correction action.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify the parts of a broaching tool.
3. Describe techniques for the cleaning and care of a broaching tool.
4. Demonstrate how to sharpen a broaching tool.
5. Discuss the importance of supports.

UNIT #6 Drilling.

LEARNING OUTCOME # 6.1 Clean, lubricate, and inspect drill press for safe operation.

TASK # 6.1.1 Clean, lubricate, and inspect drill press for safe operation.

PERFORMANCE STANDARD: Oil reservoirs must be full and all grease fittings must be greased/lubricated to manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Grease gun
Manufacturer's manual
Oil can
Personal safety equipment
Screw drivers
Wiping rags
Wrench, open/box end

PERFORMANCE STEPS:

1. Lock out drill press power.
2. Consult manufacturer's manual to determine lubrication specifications and locations.
3. Wipe clean oil points.
4. Wipe clean grease fittings.
5. Check condition of grease fittings.
   a. Replace if necessary.
6. Clean machine surface/T-slots.
7. Check oil level gauges where existent.
   a. Check for leaks.
8. Fill oil reservoirs according to manufacturer's specifications.
9. Re-check oil lever gauges.
10. Lubricate grease fittings according to specifications.
11. Lightly oil machined surfaces.
12. Wipe off excess lubricants.
13. Unlock power.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify the parts of a drill press.
3. Describe how to operate drill press.
4. Identify lubrication points from drawings.
5. Describe type of lubricants and their applications.
6. Identify solvents that can be utilized on machined surfaces.
7. Differentiate between cast iron and forged parts on drill press.

LEARNING OUTCOME # 6.2 Select, mount, and secure holding devices.

TASK # 6.2.1 Select, mount, and secure holding devices.

PERFORMANCE STANDARD: Work holding devices must be securely fastened to drill press as per manufacturer's instructions.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit
Drill press
Holding device
Workpiece

PERFORMANCE STEPS:

1. Determine operation to be performed on drill.
2. Inspect workpiece to determine technique required to hold workpiece for operation to be performed.
3. Select work holding device.
4. Secure to drill press according to manufacturer's instruction (bolt, clamp, etc.).
5. Ensure that work holding devise is secure.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify various holding devices.
3. Identify bolt threads and square thread drives.
4. Identify various types of vises.
5. Identify parts of each vise.

LEARNING OUTCOME # 6.3 Select, sharpen, and secure cutting tools.

TASK # 6.3.1 Select, sharpen, and secure cutting tools.

PERFORMANCE STANDARD: Drill bit(s) must have sharp uniform cutting edge, free of craters, nicks or burn marks. Heel must be lower than cutting lip. Cutting lips must be of equal length. Lip and relief angles must be within +- 15 minutes of drill grinding/relief gauge(s) or specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Allen wrench
Drill angle/grinding gauge
Drill relief gauge
Pedestal grinder
Personal safety equipment
Wheel dresser
Wrenches box/open end

PERFORMANCE STEPS:

1. Identify/determine angles of drill bit.
2. Inspect wheel for damage, uneven wear, eccentricity, glaze and loading.
3. Dress wheel if necessary,
4. Adjust tool rest, if necessary, to 1/8" from grinding wheel.
5. Start grinder (wheel rotation).
6. Sharpen drill bit.
   CAUTION: DO NOT ALLOW LOCALIZED HEATING. EITHER GRIND DRY OR USE A STEADY FLOW OF COOLANT.
7. Check drill bit to specifications.
8. Turn off grinder.
9. Mount bit into chuck of drill press and tighten securely with key.
10. Test drill hole.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain how to dress grinding wheel.
3. Describe techniques for cooling drill point while grinding.
4. Identify parts of drill bit.
5. Describe drill bit cutting action.
6. Identify variations of relief angle for cutting special material.
7. Describe how to calculate spindle speed of drill press.

LEARNING OUTCOME # 6.4 Layout and prepare work for drill press operation.

TASK # 6.4.1 Layout and prepare work for drill press operation.

PERFORMANCE STANDARD: Workpiece must be layed out to specifications +- 1/64". Scribed lines must be visible and single scribe mark.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Layout instruments
Blueprint/drawing	Workpiece
Layout dye	

PERFORMANCE STEPS:

1. Clean workpiece with solvent.

a. Deburr if necessary.
2. Coat workpiece with layout dye.
3. Locate reference line of drawing and workpiece.
4. Scribe center lines.
5. Prick punch and center punch centers if required.
6. Scribe circles/arc if required.
7. Scribe straight lines.
8. Check workpiece with blueprint/drawing.

ENABLING OBJECTIVES.:

1. Explain the relevant safety practices and procedures.
2. Identify from the drawing the type and size of material required.
3. Differentiate between radius and diameter.
4. Describe how to sharpen a prick punch, a center punch, and scribers.
5. Define the term tangent.
6. Identify layout dyes available.

LEARNING OUTCOME # 6.5 Select and set machine speeds and feeds.

TASK # 6.5.1 Select and set machine speeds and feeds.

PERFORMANCE STANDARD: Material (workpiece) must be efficiently with minimum of drill grinding.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Drill press
Machinist's handbook
Speed/feed charts

PERFORMANCE STEPS:

1. Determine cutting speed of material from handbook or chart.
2. Calculate spindle speed (rpm).
   NOTE: Spindle speed = $\frac{\text{cutting speed x 3.82}}{\text{diameter of cutter}}$
3. Set drill press spindle.
   a. Set exact if variable.
   b. Set to closest speed under calculated speed if pulley or gear box set.
4. Determine feed speed from machinist's handbook chart.

5. Set drill press feed at closest rate recommended.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain how to read and interpret speed/feed charts.
3. Define cutting speed, spindle speed, and feed rate.
4. List the various types of steel.
5. Differentiate between terms drill, bore counterbore, countersink, spot face,ream, and hone.

LEARNING OUTCOME #	6.6	Drill, ream, tap, countersink, counterbore, and spot face using the drill press.
TASK(S) #	6.6.1	Drill using drill press.
	6.6.2	Ream using drill press.
	6.6.3	Tap using drill press.
	6.6.4	Countersink using drill press.
	6.6.5	Counterbore using drill press.
	6.6.6.	Spot face using drill press.
TASK #	6.6.1	Drill using drill press.
PERFORMANCE STANDARD:		Holes must have smooth finish within accuracy of +- 0.005" of nominal drill size and locate within +- 0.010" of specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Center punch
Chuck wrench
Deburring tool
Drill size gauge
Inside-outside dial vernier caliper
Machinist's handbook or drilling speed/feed/drill tables
Personal safety equipment
Prick punch
Scribe
Set of drills
Small hole gauges
Table clamps or holding device

PERFORMANCE STEPS:

1. Verify workpiece material for selection of drill/speed/feed.
2. Verify specifications for size/type of hole (through or blind hole).
3. Lay out holes with scribe, prick punch, re-check location.
4. Center punch.
5. Select/mount pilot drill in chuck.
   a. Check condition of drill.
6. Secure workpiece in holding device/clamp to table.
7. Select/set speed.

8. Pilot drill.
   a. Re-check location.
9. Stop drill press.
10. Remove pilot drill.
11. Select/mount drill in chuck.
    a. Check condition of drill. Step drill and reset speed/ feed as necessary.
12. Select/set speed.
    a. Final drill.
    b. Lubricate as necessary.
13. Turn off drill press.
14. Remove drill.
15. Remove workpiece.
16. Drburr as necessary.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Describe techniques for securing work to table for drilling.
3. Differentiate between drilling, boring, counterboring, countersinking, reaming, and honing.
4. Identify using machinist's handbook for correct speed and feed rate for diameter of drill and material being machined.
5. Explain reading blueprints for layout information.
6. Describe work alignment techniques.
7. Describe how to stop the drill.
8. Identify lubricants and cutting fluids used for drilling on the drill press.
9. Describe techniques for checking the diameter and depth of a drilled hole._

TASK # 6.6.2 Ream using drill press.

PERFORMANCE STANDARD: Hole(s) must have smooth finish and snug fit on "Go" portion of plug gauge with a Total Inch Runout (T.I.R.) of 0.0001: maximum.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Chuck wrench	Personal safety equipment
Drill press with accessories	Set of drills
Machinist's handbook or tables for reaming sizes/speeds/feeds	Set of reamers
	Table clamps

PERFORMANCE STEPS:

1. Identify workpiece material.

2. Set drill press speed for drilling.
3. Select holding device and accessories.
4. Secure work in holding device.
5. Align workpiece and center drill and clamp holding device.
6. Check rigidity of set up.
7. Center drill workpiece (lubricate, as required).
8. Select drill and drill workpiece to dimensions (lubricate as required).
9. Select reamer.
10. Change drill press speed to one half drilling speed.
11. Ream hole.
    a. Mount reamer in drill press (in chuck or spindle).
    b. Use lubricant as required.
    c. Feed through workpiece.
    d. Clean and deburr hole.
12. Measure hole.
    a. Accept workpiece as within specified tolerance, or
    b. Reject workpiece.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain techniques for securing workpiece for reaming.
3. Explain how to drill, bore, and counterbore on drill press.
4. Define the term runout.
5. Identify how to set and read telescoping micrometers.
6. Describe techniques for measuring internal diameters.
7. Identify the coolants/cutting fluids for reaming.
8. Identify the calculating spindle speed of drill press for drilling and reaming.
9. Discuss the nomenclature of a ream.
10. Describe the cutting action of a ream.

TASK # 6.6.3 Tap using drill press.

PERFORMANCE STANDARD: Threads must be at specified depth, free of burrs and chatter marks, and must fit GO-NO-GO thread gauge within specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Allen wrench
Blueprints
Holding device
Machinist's handbook
Personal safety equipment
Table clamps
Tap and tapping chuck
Thread gauges (GO-NO-GO)

PERFORMANCE STEPS:

1. Select tap drill and tap as specified on blueprint (refer to machinist's handbook).

2. Mount workpiece in drill press vise.
3. Mount drill press vise on drill press table.
4. Mount and align combination drill and countersink to workpiece.
5. Select and set drill press speed.
6. Set depth stop on drill press.
7. Center drill workpiece.
8. Drill workpiece with tap drill.
9. Mount tap in tap wrench and align to drilled hole.
10. Mount dead center in drill chuck and align to tap center.
11. Hand tap hole to specifications using lubricant.
12. Check tapped hole with GO-NO-GO thread plug gauge after cleaning chips out of hole.
    a. Accept workpiece as within tolerances, or
    b. Reject workpiece.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Differentiate between national course and national fine series threads.
3. Identify taper, bottom, and plug tap.
4. Describe the term blind hole.
5. List cutting fluids and their applications.
6. Differentiate between ferrous and non-ferrous materials.
7. Describe how to power tap on drill press.

TASK # 6.6.4 Countersink using drill press.

PERFORMANCE STANDARD: Surface must be smooth and free from burrs and chatter marks, and must be concentric with hole in accordance with specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATIONS(S):

Countersinks
Drill press with accessories
Holding device
Machinist's handbook
Personal safety equipment
Table clamps

PERFORMANCE STEPS:

1. Verify workpiece material for countersink selection and cutting speeds/feeds.
2. Select/mount countersink.
3. Secure workpiece in holding device/clamp to table.
4. Align countersink with hole in workpiece.
5. Select/set speed.
6. Start drill press.
7. Countersink hole.
    a. Lubricate as necessary.

8. Turn off drill press.
9. Check countersink in accordance with specifications.
10. Remove countersink.
11. Remove workpiece.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Describe techniques for securing work to the table for countersinking.
3. Explain how to use the machinist's handbook for the correct speed and feed rate for countersinking the material being machined.
4. Describe work alignment techniques.
5. Describe how to drill hole(s) on a drill press.
6. Explain how to check countersink size with specifications.
7. Identify lubricants and cutting fluids used for countersinking.

TASK # 6.6.5 Counterbore using drill press.

PERFORMANCE STANDARD: Size, depth, and concentricity of counterbore must be within specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Counterbores
Drill press with accessories
Holding device
Machinist's handbook or table for selecting counterbore/speeds/feed
Personal safety equipment
Rule depth gauge
Table clamps
Workpiece (with pilot hole)

PERFORMANCE STEPS:

1. Verify material, if necessary, for counterbore selection, cutting speed and feed.
2. Select/mount counterbore to fit pilot hole.
3. Secure workpiece in holding device and clamp to table.
4. Align counterbore with pilot hole in workpiece.
5. Select/set speed control/start drill press.
6. Counterbore hole to specified depth.
   a. Lubricate as necessary.
7. Turn off drill press.
8. Check counterbore for accuracy.
9. Remove counterbore.
10. Remove workpiece.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Describe techniques for securing work to table for counterboring.
3. Differentiate between drilling, boring, counterboring, spot facing, reaming, and honing.
4. Explain how to use the machinist's handbook for determining the correct speed and feed rate for counterbore diameter and material being machined.
5. Describe work alignment techniques.
6. Describe how to drill a pilot hole.
7. Explain how to use ruled depth gauge.
8. Describe techniques for checking counterbore diameter.
9. Identify lubricants and cutting fluids used for counterboring

TASK # 6.6.6 Spot face using drill press.

PERFORMANCE STANDARD: Spot face must be smooth, free of chatter marks, true, and concentric with pilot hole according to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Depth micrometer
Drill press
Machinist's handbook
Spot facing tool
Steel rule

PERFORMANCE STEPS:

1. Identify workpiece material.
2. Select holding device and accessories.
3. Secure work in holding device and check set up for rigidity.
4. Select spot face tool and pilot.
5. Mount spot facing tool in drill press.
6. Set speed of drill.
   NOTE: See handbook.
7. Set stop for depth.
8. Align workpiece.
9. Start drill press.
10. Spot face workpiece.
    a. Lubricate.
    b. Face to dimensions.
11. Measure spot face.
12. Re-adjust depth stop and recut spot face, as required to blueprint specifications.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain the terms: drill, bore, counterbore, countersink, pilot hole, and center drill.

3. Explain how to set and read a depth micrometer.
4. Explain calculating spindle speed for drill press.

UNIT #7 Power sawing.

LEARNING OUTCOME # 7.1 Select, clean, lubricate, and inspect power saws for safe operations.

TASK # 7.1.1 Select, clean, lubricate, and inspect power saws for safe operations.

PERFORMANCE STANDARD: Saw must be lubricated according to manufacturer's specifications. Blade must be tensioned and aligned according to manufacturer's specifications. Guards must be in place and operable.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit	Lubricants
Brush	Manufacturer's manual
Cleaning solvent	Rags

PERFORMANCE STEPS:

1. Clean off all chips with brush.
2. Clean oil and dirt from saw.
3. Lubricate saw.
   NOTE: Check manufacturer's specifications.
   a. Apply grease to fittings.
   b. Apply oil to oil cups.
   c. Oil slides lightly.
4. Inspect saw.
   a. Check tension on blade.
   b. Check vertical alignment of blade.
   c. Check blade for sharpness and damage.
   d. Mount inserts and adjust to tolerance with feeler gauge.
5. Verify adjustments with short test run.
   a. Approve saw adjustments, or
   b. Reject saw adjustments and adjust to specifications.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. List the various types of power saws and their uses.
3. Identify the types of lubricants and their applications.
4. Define the function of the lubricant.
5. Identify cutting oil/coolants used with power saws.

6. Differentiate between blade application and tooth configuration.
7. Describe the operation and safety procedures of various power saws.

LEARNING OUTCOME # 7.2 Select, cut, and weld saw blades.

TASK 3 7.2.1 Select, cut, and weld saw blades.

PERFORMANCE STANDARD: Blade selected must meet job requirements. Blade must be straight, annealed, and without flash.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Band saw blade	Reference material
Band saw butt welder	Safety goggles
Grinder	Tin snips

PERFORMANCE STEPS:

1. Cut off electrical power to saw.
2. Remove blade tension.
3. Cut blade.
4. Grind blade ends square.
5. Insert blades in welder jaws.
   a. Point teeth in.
   b. Butt ends.
   c. Center in gap.
   d. Clamp.
6. Set pressure and weld.
   CAUTION: WEAR GOGGLES.
7. Loosen clamps and set for annealing.
8. Clamp and anneal.
   NOTE: Dull red color.
9. Remove from welder jaws.
10. Grind off flash from weld.
    CAUTION: DO NOT "DISH" GRIND WELD.
    CAUTION: DO NOT GRIND SAW TEETH.
11. Check blade in thickness gauge.
12. Remount blade and adjust tension.
13. Test run blade.
    a. Accept welded blade, or
    b. Reject welded blade and make required adjustments.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. List types of saw blades and their applications.
3. Identify the parts of a metal cutting band saw.
4. Explain how to operate a metal cutting band saw.
5. Define the term spot weld.
6. Identify the parts of a butt welder.
7. Describe the annealing process.
8. Define the term flash.
9. Describe how test tension on blade.

LEARNING OUTCOME # 7.3 Select speeds, feeds, and adjust saw.

TASK # 7.3.1 Select speeds, feeds, and adjust saw.

PERFORMANCE STANDARD: Speeds and feeds must be set as specified in machinist's handbook for workpiece.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Band saw
Machinist's handbook
Manufacturer's manual

PERFORMANCE STEPS:

1. Study blueprint.
2. Determine material to be sawed.
3. Determine type of saw to be used.
4. Determine type of blade.
5. Determine machine speed.
   a. Check speed chart on machine, if available.
   b. Check reference for cutting speed.
   c. Calculate speed, if necessary.
6. Set machine speed (consult manufacturer's operational manual).
7. Determine feed requirement and set feed.
   NOTE: Consult manufacturer's manual.

LEARNING OUTCOME # 7.4 Cut off and contour using saw.

TASK # 7.4.1 Cut off and contour using saw.

PERFORMANCE STANDARD: Workpiece must be sawed within 1/32" of scribed lines.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Band saw
Band saw blades
Layed out workpiece
Work holding device

PERFORMANCE STEPS:

1. Insure that scribed lines are clear.
2. Mount and align machine guide, as required.
3. Ensure that correct blade is on saw.
   a. Make necessary corrections.
4. Determine and set cutting speed.
5. Adjust and clamp saw guide.
6. Secure work in work holding device, as required.
7. Perform sawing operation.
   a. Support workpiece, as required.
   b. Align scribed line to blade.
   c. Advance workpiece into saw with steady pressure.
   d. Saw to specifications.
      NOTE: 1/32" from line on waste side.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify type of blades and their applications.
3. Describe how to tension blades.
4. Identify various types of band saws.
5. Explain how to layout contoured lines.
6. Identify available cutting fluid and their applications.
7. Identify the characteristics of ferrous and non-ferrous metals.
8. Explain calculating cutting speed.

UNIT #8 Operating lathe.

LEARNING OUTCOME # 8.1 Clean, lubricate, and inspect lathe for safe operation.

TASK # 8.1.1 Clean, lubricate, and inspect lathe for safe operation.

PERFORMANCE STANDARD: Lathe must be cleaned, aligned, and lubricated

to manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Brush	Manufacturer's manual
Cleaning solvent	Personal safety equipment
Lathe	Rags

PERFORMANCE STEPS:

1. Shut off power to lathe.
2. Clean off chips with brush.
3. Clean lathe with cleaning fluid.
4. Remove thick gum and grease with special solvent.
5. Lubricate lathe.
   NOTE: Check manual for lubricant.
   a. Check oil levels.
   b. Add oil up to index lines.
   c. Fill all small oil holes and cups.
   d. Wipe machined surfaces with thin oil film or rust inhibitor.
6. Clean coolant system if necessary.
   a. Remove chip and sediment trays and clean.
   b. Siphon out coolant reservoir and clean reservoir.
   c. Remove coolant nozzle and clean, then return.
   d. Clean coolant pump.
7. Replace coolant.
   NOTE: Check references.
8. Check coolant flow.
9. Turn on power to lathe.
10. Test run lathe for final check.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify the parts of a lathe.
3. Describe how a lathe operates.
4. Explain the use of cleaning solvents and their safety requirements.
5. Identify lubricants available for lathes.
6. Identify the cutting fluids/coolants used with a lathe.
7. Explain how to read blueprints to locate lubrication points.

LEARNING OUTCOME # 8.2 Set up and align lathe and attachments.

TASK # 8.2.1 Set up and align lathe and attachments.

PERFORMANCE STANDARD: Centers must be aligned to a tolerance of + or - 0.0005". Gibs must be adjusted to

manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Allen wenches	Lathe
Centers	Manufacturer's manual
Dial indicator	Test bar

PERFORMANCE STEPS:

1. Clean centers and spindle holes.
2. Mount center.
3. Check alignment of center in headstock.
   a. Regrind untrue hardened center.
   b. Turn untrue soft center.
4. Check index marks on tailstock.
5. Check centers together for rough alignment.
6. Mount test bar between centers.
7. Mount indicator on tool post.
8. Check indicator against test bar.
   a. Line indicator on center height.
   b. Move indicator against test bar about 0.010".
9. Set indicator dial at zero at one end of test bar.
10. Check test bar with dial indicator at each end.
11. Adjust tailstock to tolerance required.
12. Adjust gibs on apron to specifications.
13. Adjust gibs on compound table to specifications.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. List attachments and accessories available for lathes.
3. Describe how to clean and lubricate a lathe.
4. Define the function of a gib.
5. Describe how to set up and read a dial indicator.
6. Explain the importance of alignment.

LEARNING OUTCOME # 8.3 Turn, face, groove, and thread externally.

TASK(S) #
- 8.3.1 Turn between centers.
- 8.3.2 Face on lathe.
- 8.3.3 Turn external threads on lathe.

TASK # 8.3.1 Turn between centers.

PERFORMANCE STANDARD: Workpiece must be within tolerances of + or - 0.005" on decimal dimensions and

+ or - 1/64" of fraction dimensions and/ or meet blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprints
Center drill
Dial indicator
Lathe with accessories
Lubricant
Machinist's handbook
Micrometers

PERFORMANCE STEPS:

1. Mount workpiece in chuck.
2. Face and center drill ends.
3. Mount drive plate and centers on lathe.
4. Check center alignment.
   a. Adjust, as required.
5. Mount workpiece between centers with lathe dog attached.
6. Locate tailstock and adjust center.
   a. Lock both and lubricate center as required.
7. Check workpiece material.
8. Calculate and set speed.
9. Layout end of cut.
10. Mount lathe tool and holder.
    a. Set tool to swing away from workpiece.
    b. Check mounting at start of cut.
    c. Check mounting at lathe dog for clearance.
11. Set lathe feed for rough cut.
12. Start lathe and take trial cut short distance.
13. Stop lathe and measure workpiece.
14. Start lathe.
15. Adjust depth and rough cut 0.020" to 0.030" oversize.
16. Measure workpiece for taper and size.
17. Set lathe feed for finish cut.
18. Mount finishing tool.
19. Machine to designated dimension.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain calculating spindle speed,feed rates, and depth of cut.
3. Identify cutter bit shapes.
4. Describe cutter bit sharpening procedures.
5. Identify the techniques for additional supports for long shafts cutting.
6. Explain setting, using, care of, and reading micrometers.

TASK # 8.3.2 Face on lathe.

PERFORMANCE STANDARD: Face of workpiece must be smooth, true and square to axis of work in accordance with specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

- Dial indicator
- Engine lathe with attachments and accessories
- Four-jaw independent chuck
- Lathe manual
- Oil can w/oil
- Personal safety equipment
- Shims
- Square
- Square cutting tool bits
- Three-jaw universal chuck

PERFORMANCE STEPS:

1. Identify workpiece material for selection of cutting speeds and feed.
2. Clean and lightly oil threads on lathe spindle.
   NOTE: Some lathes have cam-lock type spindle.
3. Clean threads (or cam-stud) in chuck.
4. Mount chuck on lathe spindle.
5. Mount workpiece in chuck.

   Three-jaw universal chuck.

   a. Check and adjust for true running with shims as necessary.

   Four-jaw independent chuck.

   a. Adjust for true running by using dial indicator.
6. Mount cutting tool bit in tool holder.
   a. Adjust as necessary
7. Adjust cutting tool bit to center of workpiece.
8. Lock carriage to bed.
9. Select and set speed and feed.

   Small pieces.

   a. Hand feed.

   Large pieces.

   a. Use power cross-feed.
10. Face material to specifications.
11. Shut off lathe.
12. Remove workpiece.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify various styles of cutters for the lathe.
3. Identify feed rate and speed using machinist handbook.
4. Describe how to grind and hone cutter bits.

5. Explain workpiece mounting techniques for four-jaw chucks, three-jaw chucks and collet chucks.
6. Identify cutting fluids and their applications.

TASK # 8.3.3 Turn external threads on lathe.

PERFORMANCE STANDARD: Threads must be free of burrs and cut to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

- Engine lathe with attachments and accessories
- Lathe manual
- Machinery's handbook
- Personal safety equipment
- Thread center gauge
- Tool cutting bits (ground) to proper thread form)

PERFORMANCE STEPS:

1. Chuck workpiece in lathe.
2. Select and set speed.
   a. Repeat steps 3-12, as needed.
3. Face and center drill workpiece.
4. Secure workpiece between centers.
5. Set compound rest to thread specifications (29 or 30).
6. Mount and align cutter tool but with gauge.
7. Set gear box and headstock gears.
8. Set lathe speed (slow).
9. Check movement of threading tool for length of work.
10. Start lathe.
11. Make thread dial selection.
12. Cut threads to specifications.
    a. Check pitch after first light cut.
    b. File burrs during threading operation.
    c. Use lubricant.
    d. Finish with light cuts.
    e. Check fit before completion of cuts.
13. Measure thread with GO and NO GO thread ring gauge.
    a. Accept workpiece, or
    b. Reject workpiece.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Differentiate between various thread configurations, SAE-NC, SAE-NF, METRIC, PIPE, ACME, SQUARE DRIVE.
3. Identify calculating cutting speed and feed rate using Machinist Handbook.
4. Explain the sharpening cutter bit procedure.
5. Describe using die cutters on lathe.
6. Explain rechasing threads.

LEARNING OUTCOME # 8.4 Drill, bore, counterbore, and do internal threading operations.

TASK(S) #
- 8.4.1 Drill on lathe.
- 8.4.2 Bore and counterbore on lathe.
- 8.4.3 Cut internal threads.

TASK # 8.4.1 Drill on lathe.

PERFORMANCE STANDARD: Hole must be free of burrs and chatter marks, and drilled according to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

- Center drill
- Drill holder (optional)
- Engine lathe with attachments and accessories
- Headstock chuck or faceplate
- Lathe operator's manual
- Machinery's handbook
- Personal safety equipment
- Tailstock drill chuck or tapered shank drills
- Tool post
- Twist drill

PERFORMANCE STEPS:

1. Identify workpiece material for selection of cutting speeds/feeds.
2. Mount workpiece in chuck or on faceplate.
3. Face workpiece as necessary.
4. Select/set speed for center drilling.
5. Select/mount drill in tailstock using chuck or taper shank drill.
6. Start lathe spindle.
7. Center drill hole by applying pressure on tailstock.
8. Stop lathe.
9. Select/mount drill.
10. Step drill hole by repeating steps #4 to #8 as necessary.
    a. Lubricate as necessary.
11. Shut off lathe.
12. Check hole to specifications.
13. Remove drill/attachments.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify cutter feed rate and speed using machinist handbook.
3. Describe mounting workpiece in three-jaw and four-jaw chuck.
4. Identify sharpening drill bit procedures.
5. Explain step drilling.

6. Identify cutting fluids available and their applications.

TASK # 8.4.2 Bore and counterbore on lathe.

PERFORMANCE STANDARD: Hole must have smooth finish free of chatter marks and depth must be within + 1/64, diameter within +/- 0.003", and location within +/- 0.010".

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

- Adjustable wrench
- Boring bar and holder
- Cutting tools (sharpened)
- Engine lathe with attachments and accessories
- Lathe manual
- Machinery's handbook
- Micrometer
- Personal safety equipment
- Steel scale
- Telescope gauges

PERFORMANCE STEPS:

1. Chuck workpiece in lathe.
2. Select and set lathe speed.
   a. Repeat in steps 3-12, as needed.
3. Face and square workpiece
4. Center drill workpiece.
5. Step drill workpiece to within 1/8" of bore diameter.
6. Select boring bar.
   NOTE: Boring bar should be as large as possible.
7. Select boring tool.
   a. Check for sharpness.
   b. Check for clearance.
8. Mount boring bar with tool on center height.
9. Start lathe.
10. Move tool to workpiece and take light cut.
    a. Note end of cut on boring bar.
    b. Leave tool at cross slide setting when removing from cut.
11. Measure bored hole.
12. Take additional cuts until bored to designated dimension.
    NOTE: Cross feed readings are reverse of turning outside diameter.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Differentiate between terms boring and counterboring.
3. Describe all of the methods for drilling holes on a lathe.
4. Demonstrate mounting workpiece in universal three-jaw chuck and four-jaw independent chuck.

5. Explain the procedure for sharpening the bore cutter.
6. Determine the cutter feed rate and speed using machinist handbook.
7. Discuss the importance of selecting the proper tools.

TASK # 8.4.3 Cut internal threads.

PERFORMANCE STANDARD: Threads must be free of burrs and must be cut to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Boring bar
Engine lathe with attachments and accessories
Lathe manual
Machinery's handbook
Personal safety equipment
Scale
Thread plug gauges
Tool bit ground to thread form

PERFORMANCE STEPS:

1. Identify material of workpiece for selection of drills, cutting speeds and feed.
2. Chuck workpiece in lathe.
3. Face workpiece.
4. Center-drill workpiece.
5. Step-drill as necessary.
   a. Lubricate as necessary.
6. Bore hole to minor diameter of threads.
7. Set compound rest to specifications.
8. Mount and square boring bar using center gauge.
9. Set up Quick-Change gear box.
10. Make thread dial selection.
11. Turn on lathe.
12. Cut threads to specifications.
13. Turn off lathe.
14. Check threads with thread plug gauge.
15. Remove workpiece.
16. Remove tool bit.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. List the limitations of cutting internal threads with a boring bar.
3. Differentiate between various thread configurations, SAE-NC, SAE-NF, Metric, Pipe, Acme, Square Drive.
4. Explain how to calculate the cutting speeds and feed rate using machinist's handbook.
5. Demonstrate how to sharpen the cutter bit.
6. Explain rechasing threads.

7. Describe hand tapping on lathe.
8. Identify ferrous and non-ferrous material.

LEARNING OUTCOME # 8.5 — Ream, tap, countersink, grind, file, and polish using a lathe.

TASK(S) #

8.5.1	Ream using a lathe.
8.5.2	Tap using a lathe.
8.5.3	Countersink using a lathe.
8.5.4	Grind using a lathe.
8.5.5	File and polish using a lathe.

TASK # 8.5.1 — Ream using a lathe.

PERFORMANCE STANDARD: Holes must be smooth, free of chatter marks and in accordance with specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

- Center drill
- Drills
- Lathe and accessories
- Lubricant
- Machinist's handbook
- Plug gauge
- Reamers

PERFORMANCE STEPS:

1. Identify workpiece material and hole diameter.
2. Set lathe speed for drilling.
3. Mount workpiece in lathe.
4. Mount drill chuck and center drill in tailstock of lathe.
5. Set lathe speed.
6. Start lathe and face workpiece.
7. Center drill workpiece.
8. Select drill.
   a. Drill hole undersize.
   b. Step drill.
9. Select reamer.
10. Set lathe speed to one-half drilling speed.
11. Ream hole in workpiece using lubricant as required.
    a. Mount reamer in tailstock drill chuck.
    b. Feed reamer into drilled hole at moderate rate.
12. Measure hole and check with plug gauge.
    a. Approve workpiece as within specifications, or
    b. Reject workpiece.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Differentiate between terms: drilling, boring, honing, and counterboring.
3. Identify the parts of a metal lathe.
4. Identify the parts of a ream.
5. Identify various types of reams.
6. Explain using machinist's handbook for calculating spindle speed.
7. Explain using inside micrometers and plug gauges.
8. Explain handling and storage of reams.

TASK # 8.5.2 Tap using a lathe.

PERFORMANCE STANDARD: Tapped hole must meet blueprint specifications and fit GO-NO-GO thread plug gauges.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprint specifications	Lathe and attachments
Center drill	Taps
Cutting oil	Tap wrench
Drill bits	

PERFORMANCE STEPS:

1. Mount workpiece in lathe.
2. Face and square workpiece.
3. Center drill workpiece.
4. Drill hole with tap drill.
5. Chamfer hole.
6. Select and secure taper tap and tap wrench.
7. Mount center in tailstock.
8. Start tap in hole.
   NOTE: Hold tailstock center against end of tap.
9. Tap hole in workpiece.
   a. Apply lubricant.
   b. Back tap occasionally to break chips.
   c. Clean out chips.
10. Tap with plug and bottom taps.
11. Clean out tapped hole.
12. Measure hole with GO and NO-GO gauge.
    a. Accept workpiece as within specifications, or
    b. Reject workpiece.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify the purpose of countering.
3. Identify parts of countersink cutter.

4. Explain calculating spindle speed.
5. Describe grinding and shaping the cutter bit.
6. Define the term chamfer.
7. Describe procedure for power tapping on a lathe.
8. Explain the term threads per inch.
9. Identify the nomenclature of threads.

TASK # 8.5.3 Countersink using a lathe.

PERFORMANCE STANDARD: Countersink hole must be within tolerance of +- 1/64" on fractional dimensions and +- 1 on angular dimensions and/or within blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprint specifications
Combination drill and countersink
Countersinking tool
Lathe and attachments

PERFORMANCE STEPS:

Using Countersink Cutter

1. Chuck workpiece in lathe.
2. Select and set lathe speed.
   a. Repeat in steps 3-6, as needed.
3. Face and square workpiece.
4. Center drill workpiece.
5. Drill workpiece.
6. Countersink to blueprint specifications.
   a. Use lubricant as required.
   b. Reduce speeds.
   c. Set stop as required.
   d. Check measurements during operation.

Using Lathe Cutter Bit

1. Follow steps 1-5 under countersink cutter.
2. Set compound rest angle.
3. Mount cutter on center in toolholder.
4. Feed tool with compound rest.
5. Check angle and reset if necessary.
6. Countersink to blueprint specifications.
   a. Use lubricant as required.
   b. Reduce speed.
   c. Set stop as required.
   d. Check measurements during operation.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify purpose of countersink.
3. Identify parts of countersink cutter.
4. Explain calculating spindle speed.
5. Describe grinding and shaping cutter bit.

TASK # 8.5.4 Grind using a lathe.

PERFORMANCE STANDARD: Ground workpiece must meet blueprint specifications with tolerance of +- 0.005".

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprint specifications	Lathe and accessories
Goggles	Micrometer
Grinding wheels and dresser	Tool post grinder

PERFORMANCE STEPS:

1. Mount tool post grinder.
   a. Check wheel for cracks.
      (1) Replace if cracked.
   b. Mount wheel guard.
   c. Put on goggles.
   d. Cover v-ways with wet cloth.
   e. Dress and true grinding wheel.
2. Mount workpiece on lathe.
3. Calculate and set lathe speed.
   NOTE: Speed is usually 80-100 rpm.
4. Set feed on lathe.
   NOTE: 0.005" to 0.007".
5. Turn on power of lathe and grinder.
   NOTE: Work should turn into grinding wheel.
6. Engage workpiece with grinder.
7. Engage longitudinal feed and grind workpiece.
8. Measure workpiece with micrometer.
9. Check for taper and adjust if necessary.
10. Continue light cuts.
11. Repeat steps 7-9 until workpiece ground to size.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify parts of tool post grinder.
3. Describe dressing grinding wheel.
4. Describe wheels, shapes, and grades available.

5. List applications for grinding on lathe.
6. Identify possible problems arising with grinding operations and their remedies.
7. Identify cutting speeds and depths of cut calculations.

TASK # 8.5.5 File and polish using a lathe.

PERFORMANCE STANDARD: Workpiece must be within + 0.002 to + 0.003 oversize of specifications after filing. Workpiece must be +- 0.0005 of specifications after polishing.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprint specifications	Lathe and attachments
Cutting oil	Micrometer
File	Polishing abrasives
File card	

PERFORMANCE STEPS:

1. Mount workpiece in lathe.
2. Set lathe rpm twice speed for normal turning.
3. Disengage feed rod and lead screw.
4. File workpiece.
   a. Use handle on file.
   b. Ride file on workpiece continuously.
   c. Avoid filing near lathe dog.
   d. Place rags on the ways.
5. Check diameter of workpiece.
6. Repeat steps 4 and 5 until workpiece is within specified tolerance.
7. Polish workpiece.
   a. Place rags on lathe bed.
   b. Apply cutting oil.
   c. Wrap abrasive cloth around file.
8. Repeat step 7 until workpiece is within specified tolerance.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Describe file shapes and cuts.
3. Identify abrasives and the grit numbering.
4. Explain how to set and read micrometers.
5. Explain cutting oils available and their action.
6. Describe techniques for cleaning files.

LEARNING OUTCOME # 8.6 Machine internal and external precision tapers.

TASK(S) # 8.6.1 Machine internal precision tapers.
8.6.2 Machine external precision tapers.

TASK # 8.6.1 Machine internal precision tapers.

PERFORMANCE STANDARD: Taper surface must be machined according to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprint specifications	Internal micrometer
Boring bar with tool	Lathe and attachments
Dial indicator	Machinist's handbook
Drills	Plug gauge

PERFORMANCE STEPS:

1. Calculate taper for taper attachment from references.
2. Chuck workpiece in lathe.
3. True workpiece with dial indicator.
4. Select and set speeds.
   a. Repeat in steps 4-10 as necessary.
5. Center drill workpiece.
6. Step drill to blueprint specifications.
7. Mount boring bar holder and boring bar with tool on compound rest.
8. Adjust lathe taper attachment.
   a. Set swivel bar.
   b. Tighten binding screw.
   c. Check cross slide.
   d. Lubricate taper attachment.
9. Position boring bar and tool to blueprint specifications.
   a. Set center height.
10. Turn taper and check for accuracy.
11. Take additional cuts, checking workpiece with prussian blue and taper plug gauge.
12. Finish cut to specifications.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify cutting fluids available.
3. Demonstrate how to sharpen cutter bits.
4. Explain converting taper per inch to taper in degrees.
5. Explain using plug gauges.
6. Explain using compound rest for internal taper.
7. Describe mounting workpiece in three-jaw, four-jaw, and collet chucks.

TASK # 8.6.2 Machine external precision tapers.

PERFORMANCE STANDARD: Taper surface must be smooth, free of chatter marks, and cut according to specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprint specifications
Dial indicator
Lathe and attachments
Machinist's handbook
Micrometer
Personal safety equipment
Taper gauge

PERFORMANCE STEPS:

1. Chuck workpiece on lathe.
2. Select and set speed.
   a. Repeat in steps 3-7 as needed.
3. Face and center drill workpiece.
4. Secure workpiece between centers.
5. Set taper attachment.
   a. Position taper attachment allowing for length of taper and clamp.
   b. Set attachment for taper required.
      NOTE: See print and/or calculates.
   c. Position tool on center height of workpiece.
   d. Engage feed 1/2" before start of cut.
      NOTE: Backlash only.
6. Make roughing cut.
7. Measure workpiece and make required adjustments.
8. Check workpiece with GO and NO-GO gauge.
9. Finish cut to specifications.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify cutter bits and their cutting applications.
3. Determine the feed rate and spindle speed using machinist's handbook.
4. Describe how to grind and hone cutter bits.
5. Explain how to convert taper into degree for setting taper attachment.
6. Explain workpiece mounting techniques for four-jaw chucks, three-jaw chucks, and collet chucks.
7. Identify cutting fluids and their applications.
8. Describe other techniques for cutting external taper.

UNIT #9 Operating milling machine.

LEARNING OUTCOME # 9.1 Clean, lubricate, and inspect milling machine for safe operation.

TASK # 9.1.1 Clean, lubricate, and inspect milling machine for safe operation.

PERFORMANCE STANDARD: Milling machine must be cleaned, lubricated, and adjusted to manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Brush	Milling machine
Cleaner	Rags
Lubricants	Screwdrivers
Manufacturer's manual	Wrenches

PERFORMANCE STEPS:

1. Start milling machine and check flow gauges.
2. Stop milling machine and turn off power.
3. Clean milling machine and coolant reservoir.
4. Clean milling machine with rags.
5. Lubricate milling machine.
   a. Oil at regular intervals.
   b. Check frequency in operator's manual.
   c. Start at one point and proceed in an orderly method.
   d. Avoid over oiling and wipe off excess oil.
6. Check oil levels on sight gauges and add oil as necessary.
7. Check hand operated oiling devices.
   a. Lubricate milling machine where applicable.
8. Locate, clean, and fill all oil holes and pockets.
9. Check and clean/or replace filters.
10. Clean and oil all sliding surfaces.
11. Clean and oil exposed screws.
12. Check motor lubrication.
13. Lubricate driving chain.
14. Lubricate ball bearings and other places requiring grease.
15. Check table movement by hand and adjust gibs.
    NOTE: Refer to manufacturer's manual.
16. Check condition of milling machine and report any needed repairs.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify various types of milling machines.
3. Identify types, classifications, and kinds of milling cutters.
4. Identify cutting fluids for milling.

5. Describe how various types of milling machines operate.
6. Explain how to adjust gibs.
7. Differentiate between manual, semi-automatic, and automatic operation of milling machine.
8. Identify lubricants for milling machines.

LEARNING OUTCOME # 9.2 Set up and align milling machine and attachments.

TASK # 9.2.1 Set up and align milling machine and attachments.

PERFORMANCE STANDARD: Head must be aligned with table at tolerance of +- 0.0005".

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Dial indicator and holder
Milling machine and accessories
90 degree extension rod
Wrenches

PERFORMANCE STEPS:

1. Adjust head to zero graduation in both directions.
2. Clean table and center under spindle.
3. Mount dial indicator on 90 degree extension rod held in spindle holder.
4. Position indicator over front of table.
5. Carefully lower spindle until indicator button touches table.
6. Lower spindle until dial indicator registers about one half revolution and set on zero.
7. Lock spindle.
8. Rotate spindle 180 degrees by hand.
   NOTE: Care must be taken in this procedure.
   NOTE: Watch for T-slots.
9. Compare front and back readings.
10. Loose locking nuts and adjust head one-half reading difference and lock.
11. Recheck setting and make adjustments.
12. Raise and rotate spindle 90 degrees.
13. Repeat steps 6-11.
14. Check readings in both directions.
15. Adjust and check until table is aligned with spindle to required tolerance.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. List types of vises for milling machines.
3. List attachments available for milling machines.

LEARNING OUTCOME # 9.3 Calculate and set speeds and feeds for milling work.

TASK # 9.3.1 Calculate and set speeds and feeds for milling work.

PERFORMANCE STANDARD: Speed calculated must be within tolerance of +- 5 rpm and feed within tolerance of +- 0.001".

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprint specifications
Machinist's handbook
Micrometer
Milling cutter
Workpiece

PERFORMANCE STEPS:

1. Review blueprint.
2. Measure workpiece.
3. Determine machining specifications.
   a. Amount of stock to be removed.
   b. Number of cuts.
   c. Required finish.
   d. Workpiece material.
   e. Cutter material and size.
   f. Size of workpiece.
   g. Determine depth of cut.
4. Calculate speed of machine.
   a. Refer to machinist's handbook for formula.
   b. Round off to whole number.
5. Calculate feed of workpiece.
   a. Refer to machinist's handbook.
   b. Round off to nearest thousandth of an inch.
6. Verify calculations as within tolerance of 0.001".
   a. Accept calculations, or
   b. Reject calculations and repeat steps #1-5 until calculations are within specified tolerance.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Differentiate between down cut/climb cut and up cut/conventional cut.
3. Identify ferrous and non-ferrous material.

LEARNING OUTCOME # 9.4 End mill stock.

TASK # 9.4.1 End mill stock.

PERFORMANCE STANDARD: Surfaces must be smooth and flat to within .005". Dimensions of surfaces must be within tolerances of specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprint specifications	Micrometer
End mill cutter	Milling machine and accessories
Machinist's handbook	Personal safety equipment

PERFORMANCE STEPS:

1. Identify material for selection of cutting speeds and feed.
2. Select milling machine (horizontal or vertical).
3. Analyze/select approach method/set-up.
4. Mount and secure horizontal/vertical milling attachment.
5. Secure workpiece in vise.
6. Select/mount milling cutter (End mill).
7. Turn on machine.
8. Position workpiece to cutter.
9. Secure table and/or head clamps.
10. Select/set cutter speed.
11. Select/set table feed.
12. Engage cutter speed control.
13. Start cut manually.
14. Engage table feed control.
15. Apply coolant.
16. Mill horizontal/vertical surface to specifications.
17. Disengage feed control.
18. Disengage cutter speed control.
19. Turn off coolant flow.
20. Remove workpiece from vise.
21. Turn off machine.
22. Deburr edges of workpiece.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Identify the characteristics of an end mill cutter.
3. List applications for end mill cutters.
4. Describe other techniques for milling flat, vertical, and horizontal surfaces.

LEARNING OUTCOME # 9.5 Perform side cutter, slab, and slitting milling operations.

TASK(S) #
- 9.5.1 Perform side cutter milling operation.
- 9.5.2 Perform slab milling operation.
- 9.5.3 Perform slitting operation.

TASK # 9.5.1 Perform side cutter milling operation.

PERFORMANCE STANDARD: Workpiece surface must be smooth and machine to +- 0.005" or to blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(s):

Blueprint specifications
Milling machine and accessories
Personal safety equipment
Side cutter mill

PERFORMANCE STEPS:

1. Identify material for selection of cutting speeds and feed.
2. Select milling machine (horizontal or vertical).
3. Analyze/select approach method/set-up.
4. Mount and secure horizontal/vertical milling attachment.
5. Secure workpiece in vise.
6. Select/mount milling cutter. (Side cutter)
7. Turn on machine.
8. Position workpiece to cutter.
9. Secure table and/or head clamps.
10. Select/set cutter speed.
11. Select/set table feed.
12. Engage cutter speed control.
13. Start cut manually.
14. Engage table feed control.
15. Apply coolant.
16. Mill horizontal/vertical surface to specifications.
17. Disengage feed control.

18. Disengage cutter speed control.
19. Turn off coolant flow.
20. Remove workpiece from vise.
21. Turn off machine.
22. Deburr edges of workpiece.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Describe the characteristics of a side milling cutter.
3. List applications for side milling cutter.
4. Identify straddle milling and gang milling.

TASK # 9.5.2 Perform slab milling operation.

PERFORMANCE STANDARD: Surfaces must be smooth and flat to within .005". Dimensions of surfaces must be within tolerances of specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprint specifications	Milling machine and accessories
Machinist's handbook	Personal safety equipment
Micrometer	Slab cutter

PERFORMANCE STEPS:

1. Identify material for selection of cutting speeds and feed.
2. Select milling machine (horizontal or vertical).
3. Analyze/select approach method/set-up.
4. Mount and secure horizontal/vertical milling attachment.
5. Secure workpiece in vise.
6. Select/mount milling cutter.
7. Turn on machine.
8. Position workpiece to cutter.
9. Secure table and/or head clamps.
10. Select/set cutter speed.
11. Select/set table feed.
12. Engage cutter speed control.
13. Start cut manually.
14. Engage table feed control.
15. Apply coolant.
16. Mill horizontal/vertical surface to specifications.
17. Disengage feed control.
18. Disengage cutter speed control.
19. Turn off coolant flow.
20. Remove workpiece from vise.
21. Turn off machine.
22. Deburr edges of workpiece.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain calculation of speed and feed rates.
3. Identify techniques for securing workpiece to milling machine.
4. Identify other cutters that could be used for slab work.

TASK # 9.5.3 Perform slitting operation.

PERFORMANCE STANDARD: Workpiece slit surface must be smooth and machine to +- .005" or blueprint specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprint specifications
Milling machine and accessories
Personal safety equipment
Slitting saw

PERFORMANCE STEPS:

1. Identify material for selection of cutting speeds and feed.
2. Select milling machine (horizontal or vertical).
3. Analyze/select approach method/set-up.
4. Mount and secure horizontal/vertical milling attachment.
5. Secure workpiece in vise.
6. Select/mount milling cutter.
7. Turn on machine.
8. Position workpiece to cutter.
9. Secure table and/or head clamps.
10. Select/set cutter speed.
11. Select/set table feed.
12. Engage cutter speed control.
13. Start cut manually.
14. Engage table feed control.
15. Apply coolant.
16. Disengage feed control.
17. Disengage cutter speed control.
18. Turn off coolant flow.
19. Remove workpiece from vise.
20. Turn off machine.
21. Deburr edges of workpiece.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Describe the characteristics of a slitting saw for milling machines.

LEARNING OUTCOME # 9.6 Mill key slots.

TASK # 9.6.1 Mill key slots.

PERFORMANCE STANDARD: Key slot must have smooth finish and snug fit with mating key stock. Length of key slot must be within +- 0.010 and depth within +0.005" and -0.000". Center line position must be within +-0.005" from end of workpiece.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Blueprint specifications	Slotting attachment
Milling machine	Slotting cutter
Personal safety equipment	Vernier caliper

PERFORMANCE STEPS:

1. Mount work-holding device on mill table.
2. Identify material of workpiece.
3. Secure workpiece to table or in work-holding device.
4. Mount slotting attachment on mill.
5. Set slotting attachment at 90 degrees or required angle.
6. Position slotting attachment on table.
7. Select and mount cutter.
8. Select and adjust stroke length.
9. Align cutter to workpiece.
10. Set speed.
11. Slot to specifications.
    a. Measure workpiece after trial cut.
    b. Make adjustments as required.
12. Deburr workpiece and measure.
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action.

ENABLING OBJECTIVES:

1. Explain the relevant safety practices and procedures.
2. Explain how to set and read vernier calipers.
3. Explain complementary angles.
4. Describe techniques for securing work to milling machine.

METAL TRADES
STANDARD TOOL KIT

Calipers, inside
Calipers, outside
Calipers, vernier
Chisels, assorted, steel cold
Dial indicators
Feeler gauges (set)
Files, assorted
Flashlight, safety, 2 cell
Hacksaw
Hammer, ball peen
Hammer, chipping
Mallet, rubber
Micrometer, depth
Micrometer, external 1"
Micrometer, internal
Micrometer, telescoping
Pliers, needlenose
Pliers, regular
Pliers, side cutter
Punches, center, set of 4
Punches, pin, set of 4
Scale, 6" steel
Screwdrivers, assorted, flat
Screwdrivers, phillips, assorted
Screw extractor set
Scribes
Straightedge 1/4"x1"x24"
Spirit level
Square, combination
Tags, safety
Tape, 10 foot steel measuring
Vise grips
Wrenches, allen assorted
Wrenches, hex box/open end, 1/4"-1"
Wrenches, adjustable 6"-12"
Wrenches, pipe, 6"-12"
Wrenches, socket, 3/8" drive
Wrenches, socket, 1/2" drive

Maintenance Mechanic's Personal Safety Equipment (PSE)

Gloves
Hard hat
Safety glasses
Safety toe shoes